CERTIFICATION

IN THE MATTER of

U.S. Patent Application
Serial No. 10/642,884
of Seiko Epson Corporation

I, Takahiro Fujioka, being duly qualified to translate from the Japanese language to the English language, hereby certify that I have translated the attached document, Japanese Patent Application No. 2003-108567, filed in the Japanese Patent Office on April 14, 2003, from the Japanese to the English language, and that the attached document is a true and correct translation of said Japanese document.

Date: Feb. 9 2005

T Fujioka

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[GENERAL POWER OF ATTORNEY NUMBER] 0105458

[NECESSITY OF PROOF] Necessary

[DOCUMENT NAME] SPECIFICATION

[TITLE OF THE INVENTION] CONTAINER FOR PRINTING MATERIAL

[SCOPE OF CLAIM FOR PATENT]

[Claim 1] A container for holding a printing material therein, said container being attached to a printing device and establishing communication with said printing device via a radio wave, said container comprising:

a detector that detects a status of the printing material held in said container;

a memory unit that stores information regarding said container;

a communication module that transmits at least one of a result of the detection and the information regarding said container to said printing device;

a first electric power generator that generates a first electric power by utilizing the radio wave received from said printing device; and

a second electric power generator that generates a second electric power from the first electric power, the second electric power being supplied to both said detector and said memory unit.

[Claim 2] A container in accordance with claim 1, wherein said second electric power generator comprises a booster circuit that boosts the first electric power.

[Claim 3] A container in accordance with claim 2, wherein said booster circuit is a charge pump.

[Claim 4] A container in accordance with any one of claims 1 through 3, wherein said detector comprises a sensor of a piezoelectric element.

[Claim 5] A container in accordance with any one of claims 1 through 4, wherein said memory unit is a rewritable non-volatile memory that requires a higher voltage for rewriting or erasing a storage content thereof than a voltage required for reading the storage content.

[Claim 6] A container in accordance with any one of claims 1 through 5, said container further comprising:

a voltage drop module that drops a voltage of the electric power supplied from said second electric power generator to either one of said detector and said memory unit.

[Claim 7] A container in accordance with claim 6, wherein said voltage drop module is a circuit including at least one diode connected in series between said second electric power generator and either one of said detector and said memory unit.

[Claim 8] A container in accordance with claim 6, wherein said voltage drop module is a circuit including at least one diode connected in parallel with either one of said detector and said memory unit.

[Claim 9] A container for holding a printing material therein, said container being attached to a printing device and establishing communication with said printing device via a radio wave, said container comprising:

a first electric power generator that generates a first electric power by utilizing the radio wave received from said printing device;

multiple operating circuits that are driven at higher operating voltages than a voltage of the first electric power generated by said first electric power generator; and

a booster circuit that is shared by at least part of said multiple operating circuits and boosts the first electric power.

[Claim 10] A container in accordance with claim 6, wherein said booster circuit is shared by plural operating circuits having an equivalent operating voltage.

[Claim 11] A container in accordance with claim 6, wherein said booster circuit is shared by plural operating circuits having different operating timings.

[Claim 12] A container in accordance with any one of claims 9 through 11, said container further comprising:

a voltage drop module that drops a voltage of the electric power, which is supplied from said booster circuit to the part of said multiple operating circuits that receive the supply of electric power from said booster circuit.

[Claim 13] A container in accordance with claim 12, wherein said voltage drop module is a circuit including at least one diode connected in series between said booster circuit and the part of said multiple operating circuits that receive the supply of electric power from said booster circuit.

[Claim 14] A container in accordance with claim 12, wherein said voltage drop module is a circuit including at least one diode connected in parallel with the part of said multiple operating circuits that receive the supply of electric power from said booster circuit.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Field of the Invention]

The present invention relates to a container for holding a printing material therein, which is attached to a printing device and establishes communication with the printing device via radio waves.

[0002]

[Prior Art]

Some of ink cartridges attached to a printing device, such as an ink jet printer, have a memory that stores cartridge-related information including the production number, the production date, and the unsealing date of the ink cartridge and ink-related information including the type and the residual quantity of ink held in the ink cartridge. Some of these ink cartridges also have a sensor that detects the status of ink, for example, the residual quantity or the temperature of ink. One proposed technique directly measures the status of ink by taking advantage of a piezoelectric element, as

disclosed in, for example, the patent document 1. The prior art ink cartridge transmits various pieces of information to and from the printing device via communication, so as to manage the cartridge-related information and the ink-related information.

[0003]

Communication of the ink cartridge with the printing device is typically established by electrical connection therebetween. This prior art ink cartridge may, however, have difficulties in stable communication, due to a loose connection of a connection terminal. A recently proposed technique for stable communication utilizes radio waves to establish wireless communication of the ink cartridge with the printing device. This technique does not allow the ink cartridge to directly receive a supply of electric power from the printing device. Operating circuits in the ink cartridge are thus driven, for example, by means of an electromotive force induced by the radio waves received from the printing device.

[0004]

[Patent Document 1]

Patent Laid-Open Gazette No. 2001-147146

[0005]

[Problems to be solved by the Invention]

The ink cartridge is an expendable and the simplified circuit structure is naturally desirable. This issue is not restrictive in the ink cartridges for holding inks therein but is of great importance in containers for various printing materials, for example, in toner cartridges for holding toners therein. The object of the present invention is thus to simplify the circuit structure of a container for holding a printing material therein, which establishes wireless communication with a printing device.

[0006]

[Means for Solving the Problems and its Function/Effect]

In order to attain at least part of the above and the other related objects, the present invention is directed to a first container for holding a printing material therein. The first container is attached to a printing device and establishes communication with the printing device via a radio wave. The first container includes: a detector that detects a status of the printing material held in the container; a memory unit that stores information regarding the container; a communication module that transmits at least one of a result of the detection and the information regarding the container to the printing device; a first electric power generator that generates a first electric power by utilizing the radio wave received from the printing device; and a second electric power generator that generates a second electric power from the first electric power, the second electric power being supplied to both the detector and the memory unit.

[0007]

The 'status of the printing material' is, for example, the residual quantity, the temperature, or the viscosity of the printing material. The 'information regarding the container' is, for example, the production number, the production date, or the unsealing date of the container or the type or the residual quantity of the printing material held in the container. The container may be freely detachable from and attachable to the printing device or may be fixed to the printing device in an undetachable manner. The container may allow or prohibit refill of the printing material.

[0008]

In the first container of the invention, the second electric power is generated from the fist electric power, which is generated by utilizing the radio wave received from the printing device, and is supplied to both the detector and the memory unit. This arrangement does not require separate power supply systems for supplying electric powers to both the detector and the memory unit, thus desirably simplifying the circuit structure of the

container.

[0009]

In one preferable structure of the first container of the invention, the second electric power generator includes a booster circuit that boosts the first electric power.

[0010]

This arrangement enables the detector and the memory unit to be driven at a higher operating voltage than the voltage of the first electric power.

[0011]

In this preferable structure, the booster circuit is, for example, a charge pump. Any of diverse DC/DC converters, such as a switching regulator, may be used in place of the charge pump.

[0012]

In the first container of the invention, the detector may include a sensor of a piezoelectric element.

[0013]

The sensor of the piezoelectric element generally requires a higher operating voltage than the voltage of the first electric power generated by the first electric power generator. In the preferable structure of the invention, the second electric power generator has the booster circuit, so as to ensure a supply of a high voltage to the sensor.

[0014]

In another preferable structure of the first container of the invention, the memory unit is a rewritable non-volatile memory that requires a higher voltage for rewriting or erasing a storage content thereof than a voltage required for reading the storage content.

[0015]

For example, a non-volatile memory like an EEPROM requires a

higher voltage for writing or erasing data. In the preferable structure of the invention, the second electric power generator has the booster circuit, so as to ensure a supply of a high voltage to the non-volatile memory.

[0016]

In one preferable embodiment of the invention, the first container further includes a voltage drop module that drops a voltage of the electric power supplied from the second electric power generator to either one of the detector and the memory unit.

[0017]

For example, it is assumed that the memory unit (for example, the EEPROM) requires a relatively high voltage, while the detector requires a relatively low voltage. In this case, the second electric power generator is constructed to output the voltage required by the memory unit. The detector receives a supply of the electric power having the dropped voltage by the voltage drop module. The voltage drop module enables different electric powers to be supplied from one common voltage generator to multiple circuits that require different voltages.

[0018]

Here the voltage drop module may be a circuit including at least one diode connected in series between the second electric power generator and either one of the detector and the memory unit. The voltage drop module may otherwise be a circuit including at least one diode connected in parallel with either one of the detector and the memory unit.

[0019]

The present invention is also directed to a second container for holding a printing material therein. The second container is attached to a printing device and establishes communication with the printing device via a radio wave. The second container includes: a first electric power generator that generates a first electric power by utilizing the radio wave received from the

printing device; multiple operating circuits that are driven at higher operating voltages than a voltage of the first electric power generated by the first electric power generator; and a booster circuit that is shared by at least part of the multiple operating circuits and boosts the first electric power.

[0020]

The container may be equipped with various operating circuits, such as the sensor and the memory discussed above, which require higher operating voltages than the voltage of the electric power generated by the first electric power generator. In a container or ink cartridge for holding multiple inks therein, each ink reservoir may have a separate sensor. In the second container of the invention, the booster circuit is shared by at least part of the multiple operating circuits. This arrangement thus desirably simplifies the circuit structure.

[0021]

In the second container of the invention, the booster circuit may be shared by plural operating circuits having an equivalent operating voltage. The booster circuit may also be shared by plural operating circuits having different operating timings.

[0022]

In one preferable embodiment of the invention, the second container further includes a voltage drop module that drops a voltage of the electric power, which is supplied from the booster circuit to the part of the multiple operating circuits that receive the supply of electric power from the booster circuit.

[0023]

Here the voltage drop module may be a circuit including at least one diode connected in series between the booster circuit and the part of the multiple operating circuits that receive the supply of electric power from the booster circuit. The voltage drop module may otherwise be a circuit

including at least one diode connected in parallel with the part of the multiple operating circuits that receive the supply of electric power from the booster circuit.

[0024]

The technique of the present invention is not restricted to the containers discussed above. Other possible applications of the invention include a status measurement device like a residual quantity measurement device, a status measurement control method, a status measurement control device, corresponding computer programs for attaining these devices and method, recording media in which such computer programs are recorded, data signals that include such computer programs and are embodied in carrier waves, and a print head and a cartridge used for the printing device.

[0025]

[Description of the Preferred Embodiments]

One mode of carrying out the invention is discussed below as a preferred embodiment in the following sequence:

A. General Structure of Ink Cartridge

B. Electrical Structure of Ink Cartridge

C. Circuit Structure of Residual Ink Quantity Detector

D. Residual Ink Level Determination Routine

E. Modifications

[0026]

A. General Structure of Ink Cartridge

Fig. 1 is a perspective view illustrating the appearance of an ink cartridge 100 in one embodiment of the invention. The ink cartridge 100 has an ink tank for holding one ink therein. An ink supply opening 110 is formed in the lower portion of the ink cartridge 100 to feed a supply of ink to a print head in a printer. The top face of the ink cartridge 100 has an antenna 120 for wireless communication with the printer, a sensor SS used

to measure a residual quantity of ink, and a logic circuit 130.

[0027]

In the structure of this embodiment, a piezoelectric actuator is used for the sensor SS. The ink cartridge 100 applies a voltage onto the piezoelectric actuator to vibrate the piezoelectric element by the reverse piezoelectric effects and measures a vibration frequency of the piezoelectric element based on a variation in voltage due to the piezoelectric effects of the remaining vibration. The vibration frequency varies according to the quantity of ink remaining in the ink cartridge and is thus used as the criterion for detection of the residual quantity of ink. According to the experiments of the applicant, the frequency was equal to 90 KHz at a sufficient level of ink and was equal to 110 KHz at a substantially empty level of ink. The frequency naturally varies with a variation in volume of the ink cartridge and is thus not unequivocally determined for all ink cartridges.

[0028]

B. Electrical Structure of Ink Cartridge

Fig. 2 is a block diagram showing the structure of the logic circuit 130 included in the ink cartridge 100. The logic circuit 130 includes an RF circuit 200, a controller 210, an EEPROM 220, a residual ink quantity detector 230, an electric power generator 240, and a charge pump 250.

[0029]

The RF circuit 200 includes a demodulator unit 201 that demodulates the radio wave received from a printer PT via the antenna 120, and a modulator unit 202 that modulates an input signal from the controller 210 and transmits the modulated signal to the printer PT. The printer PT generates a carrier wave of 27.12 MHz, makes the carrier wave subjected to ASK modulation, and transmits the ASK-modulated carrier wave as control signals to the ink cartridge 100. The ASK modulation varies the amplitude of the carrier wave in response to digital signals.

[0030]

Commands and data to be sent back from the controller 210 to the printer PT, on the other hand, undergo PSK modulation by the modulator unit 202, prior to transmission. The PSK modulation varies the phase of the carrier wave in response to digital signals. The printer PT and the ink cartridge 100 communicate with each other in this manner. The modulation systems described here are only illustrative, and other modulation systems may be applicable according to the requirements.

[0031]

The controller 210 carries out various control operations according to the control signals demodulated by the demodulator unit 201. The control operations include, for example, an operation of reading information recorded in the EEPROM 220 and transmitting the information to the printer PT and an operation of transmitting a signal for detection of the residual ink quantity to the residual ink quantity detector 230.

[0032]

Various pieces of information, for example, on the production number and the production date of the ink cartridge 100 and the type of ink kept in the ink cartridge 100 have been recorded in advance in the EEPROM 220. The controller 210 reads these pieces of information from the EEPROM 220 and transmits the information to the printer PT, in response to a given instruction from the printer PT. Other pieces of information are also writable in the EEPROM 220; for example, data on the residual quantity of ink detected by a method discussed below and data on the unsealing date of the ink cartridge 100.

[0033]

The electric power generator 240 rectifies the carrier wave received by the RF circuit 200 to generate an electric power of 5 V. The electric power generator 240 corresponds to the 'first electric power generator' of the

present invention. The electric power generator 240 is connected with the RF circuit 200, the controller 210, and the EEPROM 220 and is used as an electric power supply for driving these circuit elements, although connection lines are omitted from the illustration of Fig. 2. As shown by a thick line in Fig. 2, the electric power generator 240 is also connected with the charge pump 250.

[0034]

The EEPROM 220 and the residual ink quantity detector 230 are connected to the charge pump 250. A higher voltage than 5 V, which is generated by the electric power generator240, is required to allow the controller 210 to write data into the EEPROM 220 or to vibrate the piezoelectric element of the sensor SS. In the structure of this embodiment, the EEPROM 220 and the piezoelectric element of the sensor SS are driven by an equivalent voltage at different timings. The charge pump 250 boosts the voltage generated by the electric power generator 240 and thereby generates a voltage required for allowing the controller 210 to write data into the EEPROM 220 and a voltage required for driving the sensor SS. This charge pump 250 corresponds to the 'second electric power generator' and the 'booster circuit' of the present invention. The charge pump 250 may be replaced with any of diverse boosting-type DC/DC converters, such as a switching regulator.

[0035]

C. Circuit Structure of Residual Ink Quantity Detector

Fig. 3 shows the circuit structure of the residual ink quantity detector 230. The residual ink quantity detector 230 includes two transistors Tr1 and Tr2, two resistors R1 and R2, an amplifier 232, a comparator 234, a counter controller 236, a counter 238, and an oscillator (not shown). The residual ink quantity detector 230 also has a terminal TA for inputting a charge signal from the controller 210 into the transistor Tr1, a terminal TB

for inputting a discharge signal into the transistor Tr2, a terminal TC for inputting a signal into the counter controller 236, a terminal TD for inputting a count clock from the oscillator into the counter 238, and a terminal TE for outputting a resulting count on the counter 238 to the controller 210.

[0036]

The transistor Tr1 is a PNP transistor and has a base connecting with the terminal TA, an emitter connecting with the charge pump 250, and a collector connecting with the sensor SS via the resistor R1. The transistor Tr2 is, on the other hand, an NPN transistor and has a base connecting with the terminal TB, a collector connecting with the sensor SS via the resistor R2, and a grounded emitter.

[0037]

One end of the sensor SS is grounded, while the other end of the sensor SS connects with the transistors Tr1 and Tr2 via the resistors R1 and R2 and is also linked with the amplifier 232. The amplifier 232 is further joined with the comparator 234. An output terminal of the comparator 234 is connected to the counter controller 236, and an output terminal of the counter controller 236 is connected to the counter 238. An output terminal of the counter 238 is connected to the terminal TE.

[0038]

The operations in this circuit structure are discussed below with reference to the timing chart of Fig. 4. The transistor Tr1 is set ON at a rise of the charge signal from the controller 210 to a high level. The voltage generated by the charge pump 250 is accordingly applied onto the sensor SS via the resistor R1, so that the piezoelectric element of the sensor SS is distorted by the reverse piezoelectric effects. When the controller 120 falls the charge signal to a low level and raises the discharge signal to a high level, the transistor Tr2 is set ON to discharge the sensor SS via the resistor R2.

The discharge of the sensor SS vibrates the piezoelectric element to cause a variation in voltage by the piezoelectric effects. The amplifier 232 amplifies this voltage variation. The comparator 234 compares the amplified voltage variation with a predetermined reference voltage Vref, specifies a result of the comparison as either a high-level signal or a low-level signal, and outputs the specified high-level or low-level signal to the counter controller 236. The counter controller 236 receives the input signal from the terminal TC and generates a counter control signal to validate the operation of the counter 238 for a time period corresponding to 5 pulses of the output signal from the comparator 234 since a start of the resonance vibration of the piezoelectric element. The counter 238 counts the number of pulses in the count clock input from the terminal TD, while the count control signal is at the high level (in the count enable state). The resulting count on the counter 238 is transmitted to the controller 210 and then to the printer PT. The printer PT calculates the vibration frequency of the sensor SS from the resulting count on the counter 238 and thereby determines the residual quantity of ink in the ink cartridge 100.

[0039]

D. Residual Ink Level Determination routine

Fig. 5 is a flowchart showing a residual ink level determination routine, which includes a series of processing executed by the ink cartridge 100 and a series of processing executed by the printer PT. The controller 210 of the ink cartridge 100 receives an ink quantity measurement command from the printer PT via the RF circuit 200 (step S100) and outputs the charge signal to the residual ink quantity detector 230 in response to the ink quantity measurement command (step S101). After elapse of a preset time period, the controller 210 outputs the discharge signal (step S102) and activates the counter 238 of the residual ink quantity detector 230 to count the number of pulses in the count clock (step S103). The controller 210 outputs the

resulting count to the printer PT via the RF circuit 200 (step S104). In the printer PT, the oscillator included in the residual ink quantity detector 230 has a known oscillation frequency. The printer PT calculates the vibration frequency of the sensor SS from the resulting count and determines the ink remaining status of the ink cartridge 100 according to the calculated vibration frequency (step S105). The printer PT specifies a sufficient level of ink at the frequency of 90 KHz (step S106), while specifying a substantially empty level of ink at the frequency of 110 KHz (step S107). This series of processing determines the residual quantity of ink in the ink cartridge 100.

[0040]

In the ink cartridge 100 of this embodiment discussed above, the charge pump 250 generates the electric powers, which are supplied to both the EEPROM 220 and the sensor SS. This arrangement does not require separate power supply systems for supplying electric powers to the EEPROM 220 and the sensor SS and thus advantageously simplifies the circuit structure.

[0041]

E. Modifications

The embodiment discussed above is to be considered in all aspects as illustrative and not restrictive. There may be many modifications, changes, and alterations without departing from the scope or spirit of the main characteristics of the present invention. Some examples of possible modification are given below.

[0042]

E1. Modified Example 1

In the structure of the embodiment, the ink cartridge 100 has the sensor SS for detecting the residual quantity of ink, as the detector of the invention that detects the status of ink. The sensor SS for detecting the

residual quantity of ink is, however, not restrictive at all. The sensor SS may be replaced by another sensor, such as a temperature sensor or a viscosity sensor. The ink cartridge may include multiple sensors.

[0043]

E2. Modified Example 2

The above embodiment regards application of the present invention to the ink cartridge 100 that holds one ink therein. The technique of the present invention is also applicable to an ink cartridge that holds multiple inks therein. The ink cartridge holding multiple inks therein generally has multiple sensors SS. In the ink cartridge of the invention, the booster circuit is shared by at least part of multiple operating circuits. In one modified structure, the charge pump 250 may be shared by the EEPROM and the multiple sensors. Another modified structure has two charge pumps, one exclusively used for the EEPROM and the other shared by the multiple sensors.

[0044]

E3. Modified Example 3

The above embodiment regards application of the invention to the ink cartridge that holds the ink therein. The ink cartridge is, however, not restrictive at all, but the technique of the invention may be applicable to a toner cartridge that holds a toner therein or in general to a container for holding a printing material therein.

[0045]

E4. Modified Example 4

The controller 210 is actualized by the hardware construction in the above embodiment, but may alternatively be attained by a software configuration. For example, the controller 210 may be replaced by a microcomputer including a CPU, a ROM, and a RAM. In the structure of the embodiment, the residual ink level is determined by the series of

processing executed by both the ink cartridge 100 and the printer PT. The residual ink level may, however, be determined by a series of processing executed by only the ink cartridge 100.

[0046]

E5. Modified Example 5

In the structure of the embodiment, the logic circuit 130 (Fig. 2) is designed to apply an identical voltage to the EEPROM 220 and the residual ink quantity detector 230. Different voltages may, however, be applied to the EEPROM 220 and the residual ink quantity detector 230 as shown in modified examples of Figs. 6 and 7.

[0047]

Fig. 6 shows the structure of a logic circuit 130a, which includes a voltage drop circuit 251 disposed between the charge pump 250 and the residual ink quantity detector 230. In the logic circuit 130a of this modified example, the charge pump 250 directly supplies an electric power of a voltage 20 V to the EEPROM 220, while supplying an electric power of a voltage 15.2 V via the voltage drop circuit 251 to the residual ink quantity detector 230.

[0048]

The voltage drop circuit 251 has 8 diodes connected in series and is designed by taking advantage of the stable forward voltages of the diodes at 0.6 V.

[0049]

Fig. 7 shows the structure of another logic circuit 130b which includes a voltage drop circuit 251a arranged in parallel with the residual ink quantity detector 230. In the logic circuit 130b of this modified example, the charge pump 250 directly supplies an electric power of a voltage 20 V to the EEPROM 220, while supplying an electric power of an identical voltage with an end-to-end voltage (15.2 V) of the voltage drop circuit 251a to the residual ink quantity detector 230.

[0050]

The voltage drop circuit 251a has one constant voltage diode (Zener diode) and is designed by taking advantage of the constant yield voltage (Zener voltage) of the diode.

[0051]

When there is a difference between a desired voltage and the yield voltage of the constant voltage diode, another diode may be joined with the constant voltage diode to generate a desired end-to-end voltage. The constant voltage diode may be applied for the voltage drop circuit, which is disposed in series between the charge pump 250 and the residual ink quantity detector 230 (see Fig. 6). The voltage drop circuit may be a constant voltage circuit including a transistor.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1] a perspective view illustrating the appearance of an ink cartridge 100 in one embodiment of the invention;

[Fig. 2] a block diagram showing the structure of a logic circuit included in the ink cartridge 100;

[Fig. 3] a circuit diagram showing the structure of a residual ink quantity detector 230;

[Fig. 4] a timing chart in a circuit constituting the residual ink quantity detector 230;

[Fig. 5] a flowchart showing a residual ink level determination routine;

[Fig. 6] a block diagram showing the structure of another logic circuit 130a including a voltage drop circuit 251 disposed between a second electric power generator and the residual ink quantity detector 230; and

[Fig. 7] a block diagram showing the structure of still another logic circuit 130b including a voltage drop circuit 251a disposed in parallel with the residual ink quantity detector 230.

[Description of the Symbols]

100 ... ink cartridge

110 ... ink supply opening

120 ... antenna

130 ... logic circuit

200 ... RF circuit

201 ... demodulator unit

202 ... modulator unit

210 ... controller

220 ... EEPROM

230 ... residual ink quantity detector

232 ... amplifier

234 ... comparator

236 ... counter controller

238 ... counter

240 ... electric power generator

250 ... charge pump

251 ... voltage drop circuit

251a ... constant voltage diode

SS ... sensor

[DOCUMENT NAME] ABSTRACT

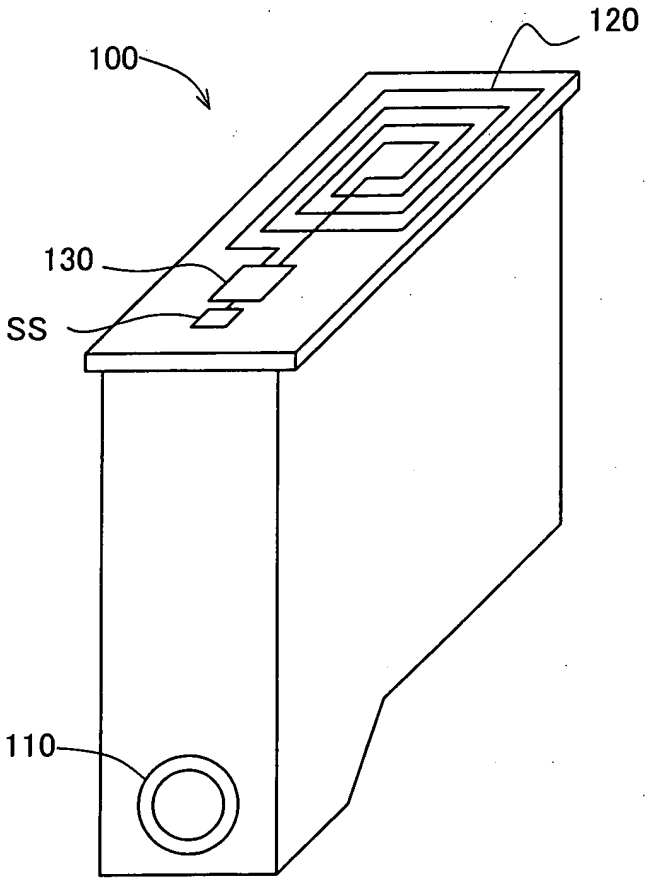
[ABSTRACT]

[OBJECTIVE] To simplify a circuit structure of a container for holding a printing material therein, which establishes wireless communication with a printing device.

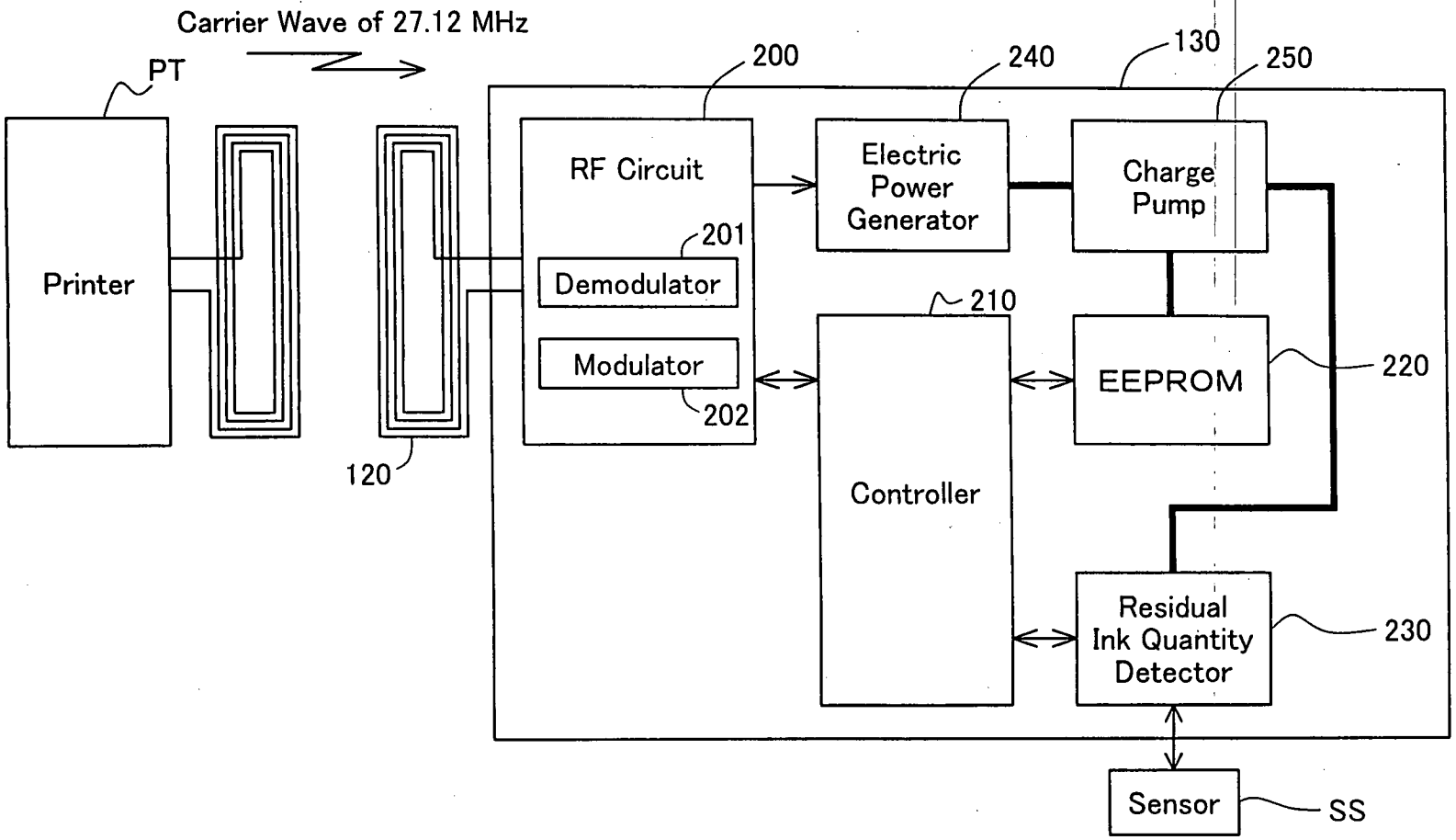
[MEANS FOR PROBLEM SOLVING] A printer and an ink cartridge use radio waves to establish wireless communication. An electric power generator 240 generates electric power through electromagnetic induction. A charge pump 250 boosts the voltage of the electric power generated by the electric power generator 240, and then supplies the electric power both to an EEPROM 220 and a sensor SS.

[SELECTED FIGURE] Fig. 2

【DOCUMENT NAME】 DRAWINGS
【Fig.1】



【Fig.2】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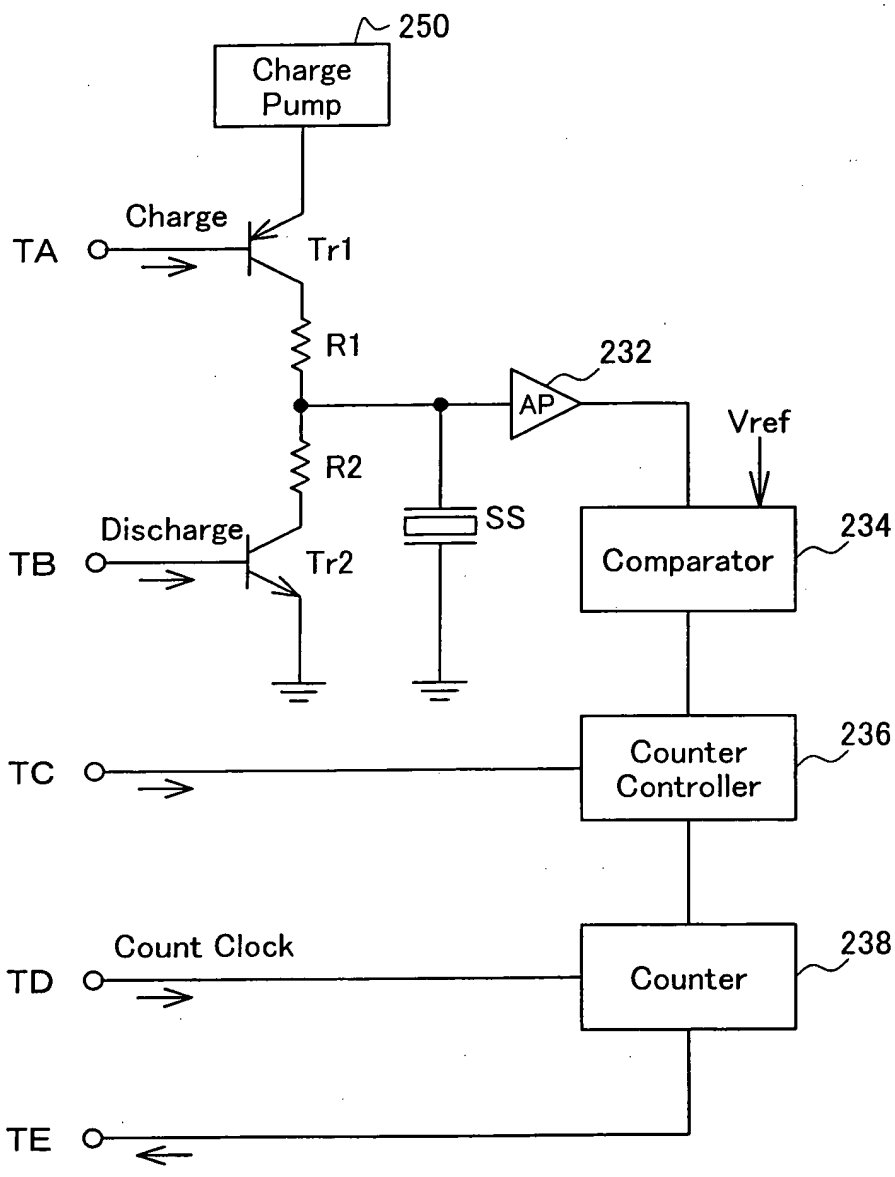
Printer
120
200
RF Circuit
201
Demodulator
Modulator
202
240
Electric Power Generator
130
250
Charge Pump
210
Controller
EEPROM
220
Residual Ink Quantity Detector
230
Sensor
SS

【Fig.3】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Charge
TA
Tr1
R1
232
AP
Vref
R2
SS
Discharge
TB
Tr2
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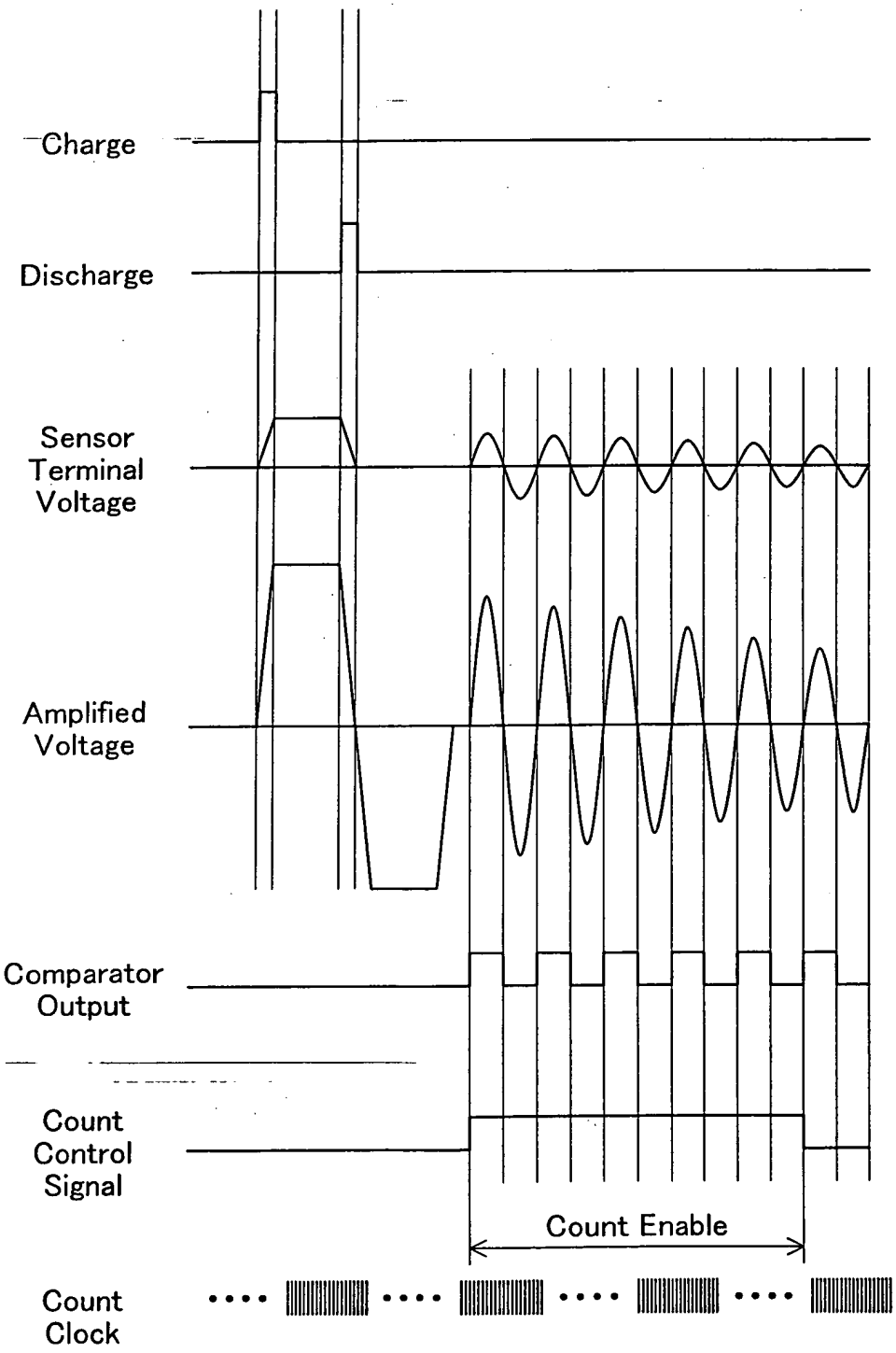
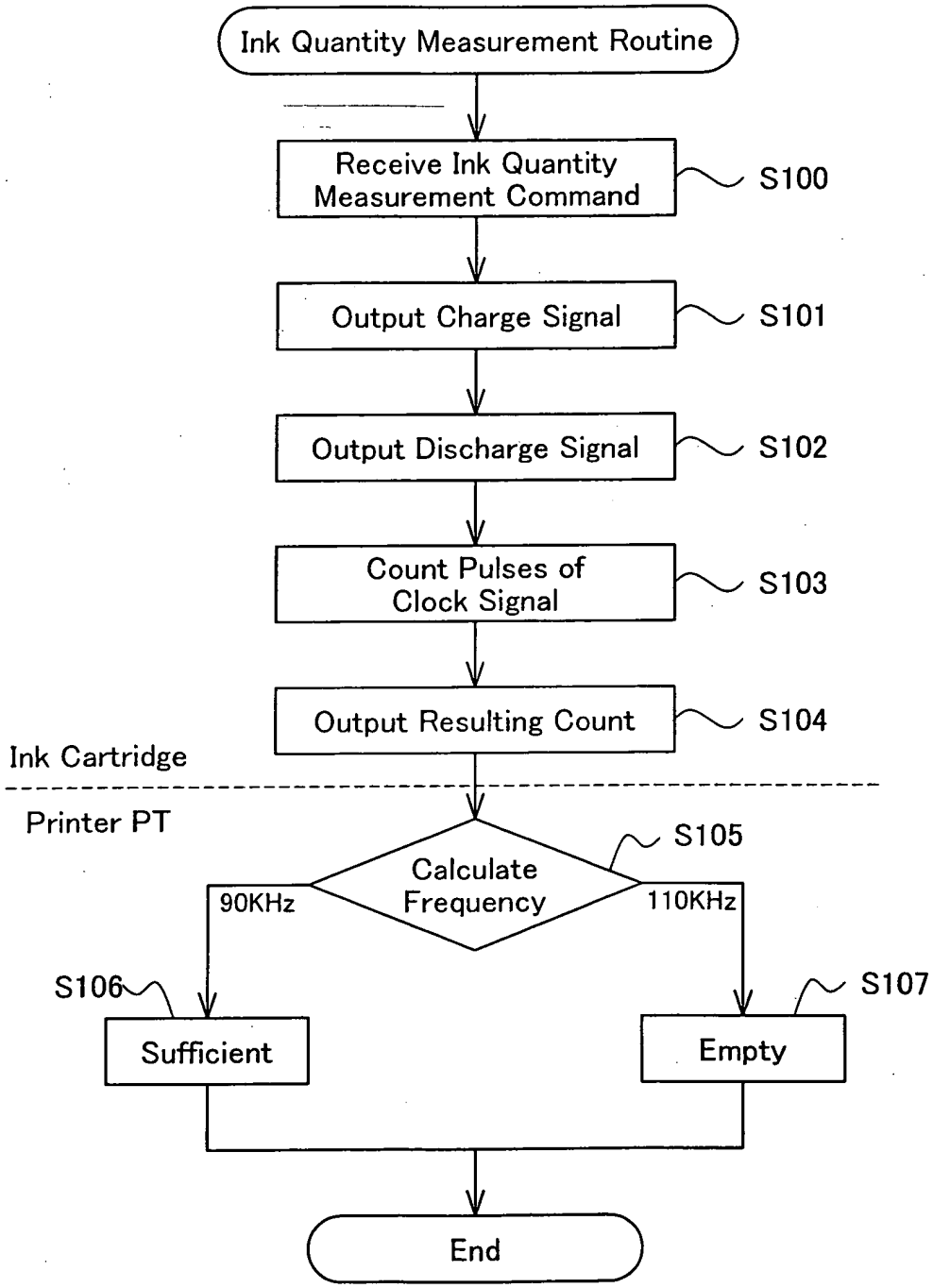
Counter Controller
236
Count Clock
TD
Counter
238
TE

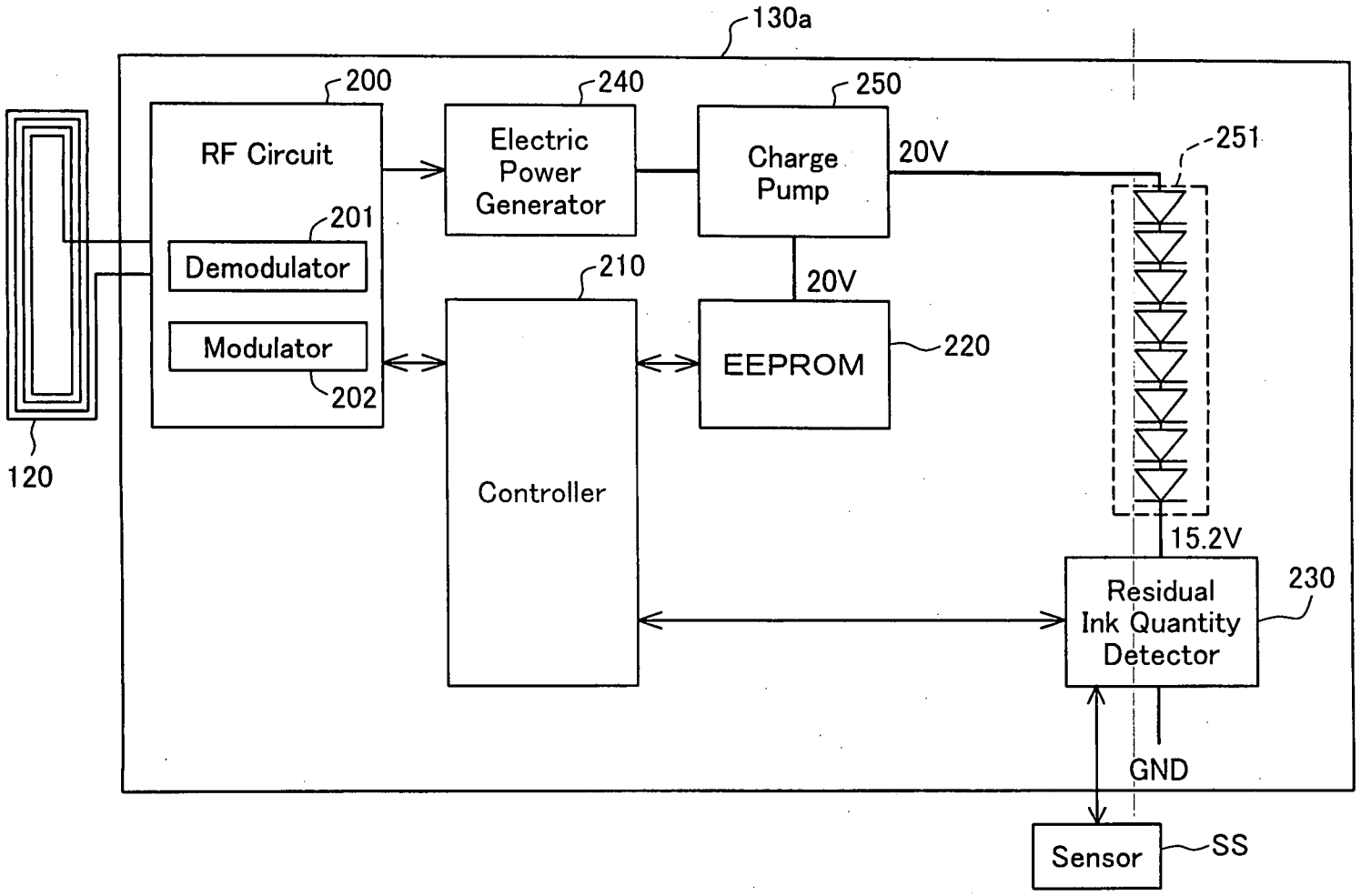
【Fig.4】


Charge
Discharge
Sensor Terminal Voltage
Amplified Voltage
Comparator Output
Count Control Signal
Count Enable
Count Clock

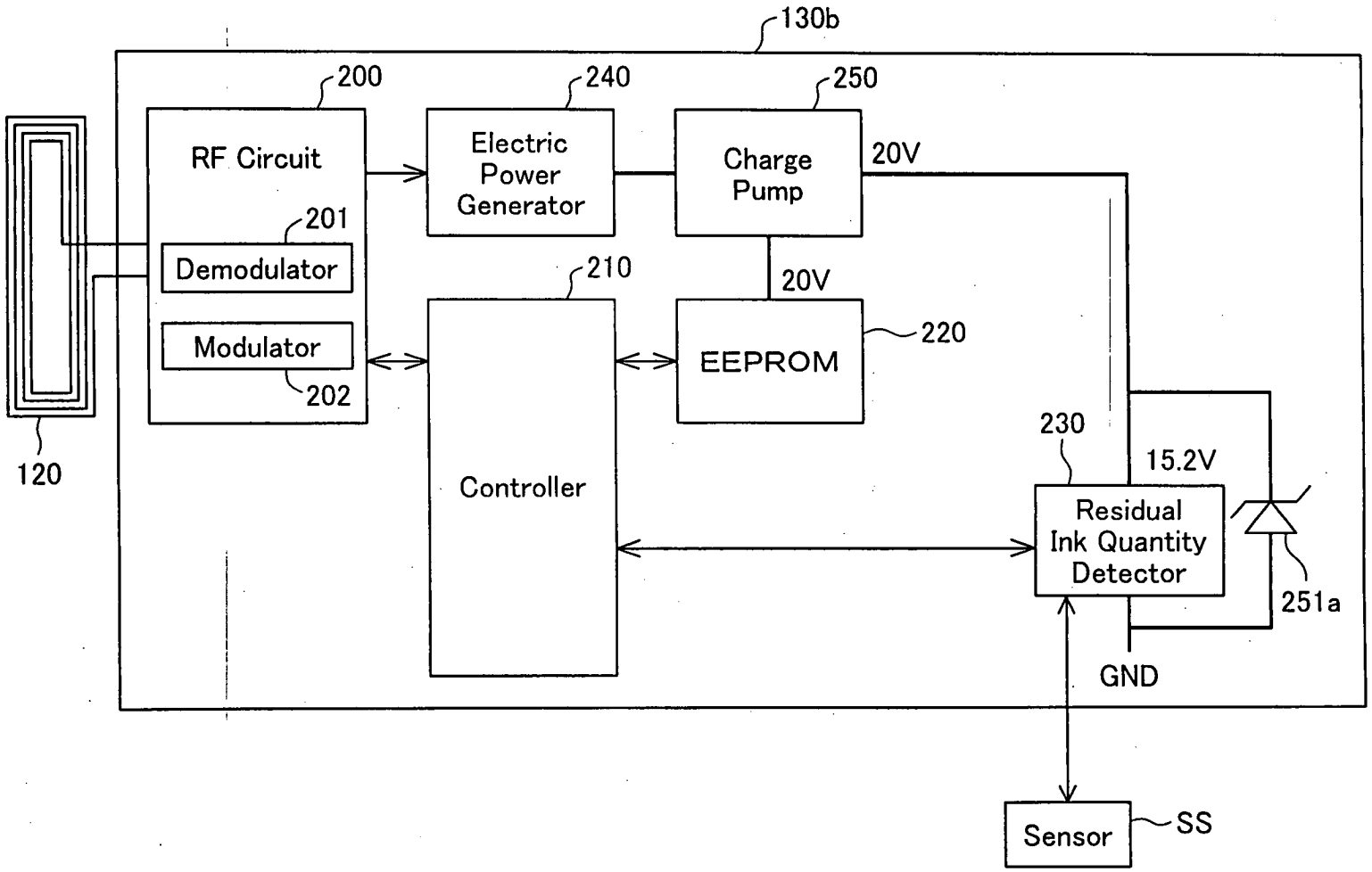
【Fig.5】


Ink Quantity Measurement Routine
Receive Ink Quantity Measurement Command
S100
Output Charge Signal
S101
Output Discharge Signal
S102
Count Pulses of Clock Signal
S103
Output Resulting Count
S104
Ink Cartridge
Printer PT
Calculate Frequency
S105
90KHz
110KHz
S106
S107
Sufficient
Empty
End

【Fig.6】


130a
200
RF Circuit
201
Demodulator
Modulator
202
120
240
Electric Power Generator
250
Charge Pump
20V
251
20V
210
Controller
EEPROM
220
15.2V
Residual Ink Quantity Detector
230
GND
Sensor
SS

【Fig.7】


130b
200
240
250
RF Circuit
Electric Power Generator
Charge Pump
20V
201
Demodulator
Modulator
202
210
20V
220
EEPROM
120
Controller
230
15.2V
Residual Ink Quantity Detector
251a
GND
Sensor
SS